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TITLE: Spread-spectrum telephony with accelerated code acquisition

Detailed Description Text (8):
Comma-Free: A code word which does not have internal repetition, i.e. which cannot be overlaid onto itself by any shift smaller than the length of the code word.

Detailed Description Text (16):
M-Sequence set: A sequence of maximum possible length generated by a linear feedback shift register having certain properties such as balance, shift and add, and correlation.

Detailed Description Text (33):
The present application discloses inventions which can be used to provide an improvement on the DoCoMo system. As in the DoCoMo system, a long-code-masked symbol common to all base stations, SC0, is broadcast repeatedly. However, instead of a single repeated symbol being combined with the universal short code symbol, a longer code is broadcast, symbol by symbol, on the second long-code-unmasked channel. Each symbol of this longer code can easily be recognized by the mobile receiver. For example, if the short codes on the second perch channel are each permitted to have one of four values, as in the DoCoMo system, and eight symbols are used for the block code, then in principle it would appear that 16 bits of information could be transmitted on the second perch channel. However, the presently preferred embodiment does not actually encode this many possibilities on the second channel, since the preferred coding also tells the receiver the phase of the code being received. This is accomplished by using "comma-free" block codes.

Detailed Description Text (37):
Second, the receiver has eliminated the phase ambiguity due to the number of repetitions of the universal code within one repetition of the long code. Again, to take a simple example, where the long code contains 16 repetitions of the unmasked universal code, the DoCoMo system requires that 16 different shift positions must be tried out for each long code candidate. By contrast, the use of a comma free block code reduces the ambiguity in shift positions. In the simple example given, if the block code is of length eight, then once a block code has been recognized there are only two possible shift positions for the long code. This greatly reduces the amount of searching required.

Detailed Description Text (38):
To take another example, forming eight-symbol blocks using an alphabet of four symbols, the raw number of possible blocks is 4.sup.8 (four to the eighth, or 65,536). Removing the codes which are not comma-free requires removal of 4.sup.4 (256) codes (since any code which repeats under a shift of one or two will also repeat under a shift of four). The remaining total of 65280 comma-free codes is divided by eight, since each possible shift of these codes will still appear. This yields 8160 unique comma-free blocks, which is still a. large number.

Detailed Description Text (40):
For example, using the simple example above of an alphabet of four symbols and a long word which contains 16 long-code-masked symbols, and a set of 128 long codes, the set of comma-free block codes of length eight is far more than necessary to uniquely identify one of the 128 long codes. Thus the number of cases which must actually be searched is two (one long code with two possible shifts). Alternatively, if a block code of length four were used in the system, the number of comma-free block codes would be exactly 4.sup.4 -4.sup.2, or 240. Here too the information in

the block code is more than enough to uniquely identify one of 128 possible long codes. In this case the number of ambiguities in the phase of a long code is four (16 divided by 4), so that the number of long code possibilities is only four.

Detailed Description Text (41):
Of the large number of comma free code words, only a small subset of these code words is chosen (e.g., only 64 of the length of code words for the (8,3) R.S. code example). This is done so that the chosen code words have a large minimum Hamming distance. This will improve performance since the chance that the receiver will misidentify one code word for another becomes smaller with a larger minimum distance. Reed-Solomon codes provide a method for deter- mining a set of code words with a large minimum distance. Preferably the codes used are chosen to minimize confusion. As discussed below, Reed-Solomon codes are particularly advantageous for this. Although originally designed as error-correcting codes, the comma free proper- ties of Reed-Solomon codes make them particularly useful for code based acquisition purposes.

Detailed Description Text (46):
The disclosed method alleviates such lengthy searches by sending an (n, k) block code over the perch channel, instead of repeatedly transmitting the group code. The k data symbols of the code encode the long code sequence ID. Since the block code is sent repeatedly, it has to have the comma-free property, i.e. cyclic shifts of every code- word must be unique. This property ensures that the code can be uniquely decoded, once n contiguous symbols of the code are collected from the perch channel. An error correcting code such as a Reed- Solomon code, with an alphabet made of the N Gold codes, is used for the block code. The MS uses soft-decision decoding to obtain the long code ID; the large minimum distance provided by the block code results in an equivalent diversity gain. In addition, the mobile can also determine the exact cyclic shift of the code-word since a comma-free block code is used. This cyclic shift information can be used to determine the long code phase; this is needed if the markers are transmitted more than once in one period of the long code, resulting in an ambiguity in the starting point of the long code with respect to the marker positions. FIG. 6 depicts a wireless communications system in which mobile stations (MS) which have acquired signals from base stations (BS). A base station is located at the center of each cell 604. The path of the BS signal to the MS which has acquired it is indicated by the directional signal arrows 602. The MS acquires the BS signal of the BS signal which is subject to the least amount of path loss while propagating to the MS.

Detailed Description Text (50):
The disclosed method, using comma-free code-words from an (8.3) Reed Solomon code over GF(17), at 0 dB average pilot SNR, for Rayleigh fading with 80 Hz Doppler Shift, yield an average acquisition time about 1 second, which is less than one third of the acquisition time for the existing group code based method.

Detailed Description Text (56):
FIG. 5 depicts the transmission structure of a base station cell. Data on the control channel (CCH) is modulated by a Quadrature Phase Shift Keying (QPSK) module. The signal is then spread by a combination of a cell site-unique long code (LC.sub.j) and the CSC (common short code) common to all cell sites. However, the long code sequence is periodically masked over one data symbol interval (or short code length) by a long code group identification code (GIC.sub.j) identifying the group to which the long code of each cell belongs. {SC.sub.0, SC.sub.1, . . . ,SC.sub.pg-1 } is the full set of orthongonal short codes and SC.sub.0 is the short code assigned to CSC while the other codes are assigned to the traffic channel (TCH). One of these short codes, other than SC.sub.0, is reused as the GIC. Two sequences are used to generate the spreading code of the j-th cell site. The first is generated by loading a generator shift register with all "1"s. The other is generated by loading a generator shift register with a binary representation of a j, where a is the shift constant unique to each cell site. The long code, LC.sub.j, is generated as LC.sub.j =PN.sub.1 ("1"s).sym.PN.sub.2 ("a.multidot.j"), where .sym. is a modulo-2 sum operation. The GIC.sub.j representing LC.sub.j is determined as GIC.sub.j =SC.sub.(j mod A)+1, where A (.ltoreq.pg-1) is the number of long code groups, each group containing 1/A times the total number of long codes used in the system.

Detailed Description Text (67):
Comma Free Codes

Detailed Description Text (68):
The offsets of the long code can also be encoded in the block code using comma free codes. Since the block code is transmitted repeatedly, the receiver may get an arbitrary cyclic shift of the block code C.sub.1 C.sub.2 . . . C.sub.n. Each code word is characterized by its period, which is defined as the number of cyclic shifts of the code word that are unique. For example, for a binary code, an all one or an all zero code word has period of 1 whereas an alternating 0-1 sequence will have period 2. Clearly, for a lengthy code, e.g., of length n, there will be some code words that have period n, i.e. all n cyclic shifts of the code word (corresponding to cyclic shifts of 0 through n-1) will be unique. If a code word of length n has a period p, then p divides n. Thus, if n is a prime, then the only periods possible are 1 and n. For example, for all binary sequences of length 3: {000, 111 } have period 1, and the other 6 sequences {100, 010, 001, 110, 101, 011} each have period 3.

Detailed Description Text (69):
For the purpose of long code identification, the period of a code word has a relationship to the number of bits of information it carries. This is because the unique cyclic shifts of a code word can be used to encode the possible offsets of the long code. For this to be true, however, the length of the code word n must divide the number of possible offsets of the long code with respect to the long code masked symbol locations, 16 in this example. FIG. 3 depicts a block code of n=8.

Detailed Description Text (70):
The symbol C.sub.1 of the code word can be synchronized to start at the beginning of the long code period. If only code words that have all 8 unique cyclic shifts (i.e. have a period 8) are used, then the receiver only needs to look at two possible offsets of the long code. On the other hand, code words with periods smaller than 8 encode lesser information: a period of 4 implies an offset ambiguity of 4, and these 4 offsets still need to search. An example of a length 8 binary code word that has period 4 is 10111011.

Detailed Description Text (74):
Since the above M code words comprise the set of all code words that have n unique cyclic shifts, they can be divided into M/n disjoint classes, with each class containing all the cyclic shifts of a particular code word i.e. M/n unique groups. The equation above illustrates that a large percentage of the q.sup.n n-tuples are in fact comma free: the subsequent terms are exponentially smaller than the first term.

Detailed Description Text (75):
As a special case of the above equation, consider where n=p.sup.1 is a prime, then M=q.sup.n -q.sup.n/p. For example, if n=4, and q=2, then there are 12 comma free codes: {0001, 0010, 0100, 1000, 0111, 1011, 1101, 1110, 1001, 1100, 0011, 0110}. The 3 classes consisting of codes that are cyclic shifts of one another are: {0001, 0010, 0100, 1000}, {0111, 1011, 1101, 1110}, and {1001, 1100, 0011, 0110}. Thus, there are three unique groups.

Detailed Description Text (76):
Using any one code word from each of the M/n classes, up to M/n long code groups can be encoded. In addition, since the code words are comma free and n is chosen to divide, in this example, 16, only 16/n offsets need to be searched. The number of symbol intervals required in stage 3 to complete the search (without any diversity combining) for the comma free code based approach is:

Detailed Description Text (77):
Note, had a code length that does not divide 16 been used, symbol intervals would be required. On the other hand, if n does divide 16, but a comma free code is not used, then each code word carries a different amount of information depending on its period, complicating decoding.

Detailed Description Text (78):
Simple Comma Free Code of Length 2

Detailed Description Text (79):
A total of 512 long codes (L=512) are assumed. Instead of a single symbol group code, an n=2 comma free code can be employed. If q=16 is chosen, M/n results, whereas q=17 gives M/n=136. Thus 7 bits using an alphabet set of size 17 can be encoded, which encodes 128 long code groups (N=128), each containing 4 long codes. If short codes SC1 to SC17 are used as the alphabet for the length 2 code described above, code words will be 128 ordered pairs of the form (SC1, SC2), (SC1, SC3), etc. If (SCi, SCj) is chosen as a code word, then (SCj, SCi) is not used as a code word. Also, for each code word (SCi, SCj), i is not equal to j for the comma free property to hold. The first element of each code word is aligned to the start of the long code period, as shown in the example of FIG. 3. The receiver receives both cyclic shifts of each code word on perch 2. The acquisition task at the receiver now is again divided into 3 stages:

Detailed Description Text (82):
Stage 3: Since each group consists of 4 long codes, with an offset ambiguity of 8, a total of 32 combinations need to be searched.

Detailed Description Text (85):
Code diversity can be exploited by taking comma free codes a step further by using error correcting block codes to send long code information on perch 2. Reed Solomon codes yield not only the benefits of a small search space as indicated before, but also improved performance in the second stage of acquisition thanks to the error correcting property of the code.

Detailed Description Text (86):
An error correcting code achieves its useful properties because it is designed such that all its code words have a certain minimum distance between them; a t error correcting code has minimum distance 2t+1. All cyclic shifts of each code word are also received at the receiver. Thus a code in which all cyclic shifts of a code word are also code words is needed. In other words, a cyclic code is needed. This is of course not a problem because a significant body of coding theory literature in fact deals with cyclic codes.

Detailed Description Text (87):
Any error correcting cyclic code with block length n that divides, e.g., 16 can be used for the purpose of long code identification. Comma free code words from such a code must be chosen, i.e. the code words that have n unique cyclic shifts, are used to encode the long code group.

Detailed Description Text (89):
Counting Comma Free Code Words

Detailed Description Text (92):
The value c is arbitrary and is normally chosen to be 1. However, for maximizing the number of comma free code words in the generated code, the optimal value for c is in fact 0. Thus an (n,k) RS code C is constructed using a generator polynomial with the roots 1, .beta., .beta..sup.2 . . . , .beta..sup.n-k-1.

Detailed Description Text (94):
When compared to the above equation for n-tuples over a q-ary alphabet, a large proportion of the q.sup.k code words in the RS code are seen to be comma free. However, if the roots of the generator polynomial of the code are stated to be .beta..sup.c, .beta..sup.c+1, . . . , .beta..sup.c+n-k-1 such that c is not equal to 0, then the number of comma free code words reduces to: ##EQU4##

Detailed Description Text (95):
A procedure, the Bose-Caldwell technique, for generating a subset of comma free code words from an arbitrary cyclic code given the generator polynomial for that code, has been derived. See W.W. Peterson and E. J. Weldon, ERROR CORRECTING CODEs 374-91 (1972). Applying the procedure to RS codes, any (n,k) RS code will generate nq.sup.k-1 comma free code words; thus q.sup.k-1 long code groups can be encoded

using these code words. In other words the comma free property can be achieved by giving up one information symbol. However, it can be shown that there are in fact more comma free code words in a given RS code than the nq.sup.k-1 code words obtained by the Bose-Caldwell technique.

Detailed Description Text (96):
The Bose-Caldwell technique has another property in that given cyclic shifts of the generated code words, a syndrome polynomial can be constructed that uniquely determines the cyclic shift. Thus during decoding the receiver avoids comparing all the cyclic shifts of the received code word to each of the possible transmitted code words. However, to get the most out of the code based approach, soft decision decoding of the RS code at the receiver is required. Although using soft decoding means the efficient decoding techniques available both for regular decoding of the RS code as well as for determining the cyclic shift cannot be used, complexity is not a problem for the short length (n=8) RS codes being considered.

Detailed Description Text (97):
Reed Solomon Code Comma Free Code Words

Detailed Description Text (98):
For the code based acquisition scheme the block length n that divides, e.g., 16, is chosen. RS codes over GF(17) are most suitable for this, since these codes have block length that divides 16. The (8,2) code has M=272 comma free code words (found by machine search, as opposed to only 136 code words generated by the Bose-Caldwell technique). Therefore, M/n=34 long code groups can be encoded with such a code.

Detailed Description Text (100):
M=173-17=4896 comma free code words are obtained. An interesting aside, though not of great consequence here, is that if

Detailed Description Text (101):
only 17.sup.3 -17.sup.2 =4624 comma free code words are obtained.

Detailed Description Text (102):
The 4896 comma free code words in the (8,3) code (using generator g(X)) may be divided into 4896/8=612 classes of code words, each containing 8 cyclic shifts a code word. Thus up to 612 long code groups can be encoded using any one code word from each of these 612 classes. As an example, let the number of long code groups to be 64, using only a subset of the 612 classes. This choice is convenient for comparing the performance of the RS code based approach with the original NTT approach as well as with the simple length 2 code. Assume there are 512 long codes in the system, divided into 64 groups (N=64) leaving 8 long codes per group. The first symbol of each of these 64 code words is aligned to the start of the long code period, as in FIG. 3. The receiver receives every cyclic shift of each code word, a total of 64.times.8 code words in all. However, since it knows the particular cyclic shift that has been transmitted, it determines the start of the long code period, but for an ambiguity of 2 offsets.

Detailed Description Text (107):
For hard decision decoding, the receiver simply determines the SCj that yields maximum correlation in each of the 8 consecutive slots. This determines each C.sub.1, at which point the standard RS decoding algorithm can be used to correct up to 2 errors (since 2t=n-k=8-3). Which of the 64 code words the received word corresponds to can then be determined, either using the Bose-Caldwell approach, or by exhaustively comparing the received word with each of 8 cyclic shifts of each of the 64 code words. This is a simple task for a DSP. This yields the code word that was transmitted as well as the particular cyclic shift that was received.

Detailed Description Text (108):
For soft decision (maximum likelihood) decoding, the 8.times.17 results obtained from the correlation process are saved. Let D.sub.i be the result of correlating the received signal in the ith time slot (1.ltoreq.i.ltoreq.8 represents each of the 8 consecutive time slots) with the short code SCr, 1.ltoreq.r.ltoreq.17. If diversity combining of order d is employed, then each D.sup.i represents the combined correlation value from the d time slots. Now, for each of the 8 cyclic shifts of

each one of the 64 code words that may have been transmitted (512 candidates in all), the following decision variable is calculated: ##EQU5##

Detailed Description Text (109):
where C.sub.1 +L C.sub.2 +L . . . . C.sub.8 +L are each of the 512 possible candidates, one of which is the received cyclic shift of the transmitted code word C.sub.1 C.sub.2 . . . C.sub.8.

Detailed Description Text (110):
The word C.sub.1 +L C.sub.2 +L . . . C.sub.8 +L that maximizes A is chosen, and in this search process, the cyclic shift of the received code word can also be determined. To do this efficiently, for each of the 64 code words C.sub.1 C.sub.2 . . . C.sub.g, calculate .LAMBDA. for it and its cyclic shifts, and store the maximum value of .LAMBDA. (out of 8 computed values) that is obtained, and also store the cyclic shift corresponding to this maximum. This is done for all 64 code words, in the end obtaining the most likely transmitted code word and also its received cyclic shift. The large minimum distance between the code words and their cyclic shifts reduces the probability of picking a wrong code word, i.e. provides code diversity.

Detailed Description Text (112):
Stage 3: Since each group consists of only 8 long codes with an offset ambiguity of 2, a total of 16 combinations need to be searched, as compared to 512 combinations in the NTT scheme, and 32 combinations needed if the simple length 2 comma free code or the (8,2) RS code is used.

Detailed Description Text (115):
For example, employing 16 correlator fingers and using 4 time slots in stage 3, a diversity of 18 for the length 2 comma free code is obtained, because there are 9 unmasked symbols per time slot and it takes 2 symbols to search through 32 long code and offset combinations on 16 fingers. On the other hand using 4 time slots a diversity of 36 for the comma free code derived from the (8,3) RS code is obtained, whereas 4 time slots allows for no diversity combining in the NTT approach.

Detailed Description Text (125):
Stage 2 is entered both because of a correct detection in stage 1 (corresponding to state S2a in FIG. 4) and because of a false alarm in stage 1 (state S2b). In stage 2, for the original NTT proposal, the received signal y is correlated with the short codes SC1 to SCN, at the position at which the long code masked symbol is expected (from stage 1). The hypothesis chosen is the one that has a maximum correlation. This maximum correlation output is also compared to a threshold .tau..sub.2, and a hit occurs only if it is exceeded. When a hit occurs, move on to stage 3, otherwise go back to stage 1. This reduces errors due to mistakes in stage 1. Again, a post detection diversity combination for T.sub.2 time slots may be performed. To summarize, the test performed at this stage, for the original NTT scheme, is: ##EQU7##

Detailed Description Text (128):
where (c.sub.0.sup.r,c.sub.2.sup.r, . . . c.sub.255.sup.r), 1.ltoreq.r.ltoreq.17, are the short Gold codes SC1 through SC17 that make up the alphabet of the length n group codes C.sub.1 C.sub.2 . . . C.sub.n ; C.sub.i (with 1.ltoreq.C.sub.i.ltoreq.17) corresponds to one of the short codes SCi; and i (with 1.ltoreq.i.ltoreq.n) represents each of the n consecutive time slots. The group code and its received cyclic shift is estimated by computing the decision variable .LAMBDA.(.LAMBDA. corresponds to the Euclidean distance between the received n-tuple and each of the possible transmitted n-tuples): ##EQU9##

Detailed Description Text (129):
where C.sub.1 +L C.sub.2 +L . . . C.sub.n +L are each of the transmitted group codes and their cyclic shifts.

Detailed Description Text (139):
Stage 3 is entered both because of a correct decision in stage 1 (corresponding to state S3a in FIG. 4) and because of errors either in stage 1 or stage 2 (state S3b). At Stage 3 the long code group has already been determined. However, which long code within that group is being used, and its offset must be determined. Each of the long

code candidates is searched by correlating the received signal with the corresponding long code and offset, using T.sub.3 time slots (which may include post detection diversity combination), and finding out which hypothesis leads to maximum correlation output. The correlation operation has to be performed over symbol intervals corresponding to the unmasked portion of the perch 1 channel.

Detailed Description Text (141):
since there are 9 unmasked symbols per time slot can be utilized. With 16 fingers, the above equation implies a diversity of T.sub.3 /4 for the original NTT group code scheme, it implies a diversity of 9(T.sub.3 /2) for the length 2 comma free code example above, and a diversity of 9T, for the comma free code derived from the (8,3) RS code.

Detailed Description Text (165):
A method for reducing the long code search in WCDMA systems that results in lower acquisition time is disclosed. The method uses an error correcting block code sent over the second perch channel, and makes use of the comma free property of code words. Simulation results using a Rayleigh fading channel model show a factor of 2 to 3 improvement in acquisition time compared to the existing scheme employed in the NTT DoCoMo specification while supporting 4 times the number of long codes, keeping available hardware and the probability of false lock constant. The only extra processing required is for the maximum likelihood decoding of the group code during stage 2 of the acquisition process; this is estimated to consume less than 10 K DSP processor cycles for the (8,3) Reed Solomon code example. Thus, this method can be used for reducing time to acquire the received code at low SIRs, using simple hardware.

Detailed Description Text (170):
Further details of the system context and of options for implementation may be found in Glover, DIGITAL COMMUNICATIONS (1998); S. Glisic and B. Vucetic, SPREAD SPECTRUM CDMA SYSTEMS FOR WIRELESS COMMUNICATIONS (1997); A. Viterbi, CDMA: PRINCIPLES OF SPREAD SPECTRUM COMMUNICATIONS (1995); K. Feher, WIRELESS DIGITAL COMMUNICATIONS, MODULATION AND SPREAD SPECTRUM APPLICATIONS (1995); R. Peterson et al., INTRODUCTION TO SPREAD SPECTRUM COMMUNICATIONS (1995); M. Simon et al., SPREAD SPECTRUM COMMUNICATIONS HANDBOOK (2.ED.1994); R. DIXON, SPREAD SPECTRUM SYSTEMS (3.ed. 1994); R. E. Blahut, THEORY AND PRACTICE OF ERROR CONTROL CODES, Addison-Wesley Publishing Company, 1983; D. Chase, A CLASS OF ALGORITHMS FOR DECODING BLOCK CODES USING CHANNEL MEASUREMENT INFORMATION, IEEE Transactions on Information Theory, Vol. IT-18, January 1972; A. G. Dabak, SYSTEM ENGINEERING FOR BUILDING WCDMA MOBILE RECEIVER, TI Technical Activity Report, January 1998; G. D. Forney, GENERALIZED MINIMUM DISTANCE DECODING, IEEE Transactions on Information Theory, Vol. IT-12, April 1966; W. C. Jakes, MICROWAVE MOBILE COMMUNICATIONS, IEEE Press, 1974; V. M. Jovanovic, and E. S. Sousa, ANALYSIS OF NON-COHERENT CORRELATION IN DS/BPSK SPREAD SPECTRUM ACQUISITION, IEEE Transactions on Communications, Vol. 43, No. 2/3/4, February 1995; K. R. Matis, and J. W. Modestino, REDUCED-STATE SOFT-DECISION TRELLIS DECODING OF LINEAR BLOCK CODES, IEEE Transactions on Information Theory, Vol. IT-8, January 1982; SPECIFICATIONS FOR MOBILE EQUIPMENT, NTT Mobile Communications Network, Inc., April 17, 1997; A. Papasskellariou, PILOT PN ACQUISITION FOR IS-95A, TI Technical Activity Report, July 1997; W. W. Peterson, and E. J. Weldon, ERROR CORRECTING CODES, Second Edition, The MIT Press, 1972, pp. 374-391; J. G. Proakis, DIGITAL COMMUNICATIONS, McGraw Hill Book Company, 1989; J. K. Wolf, EFFICIENT MAXIMUM LIKELIHOOD DECODING OF LINEAR BLOCK CODES USING A TRELLIS, IEEE Transactions on Information Theory, Vol. IT-24, January 1978; all of which are hereby incorporated by reference.

Detailed Description Text (171):
According to a disclosed class of innovative embodiments, there is provided: a method of spread spectrum communication, comprising the action of: transmitting a signal which at least intermittently includes both first data which has been spread by a first long code, and also second data which is transmitted intermittently, and has not been spread by said first long code; wherein multiple transmissions of said second data, in combination, provide at least partial identification of said first code.

Detailed Description Text (172):

According to another disclosed class of innovative embodiments, there is provided: a method of spread spectrum communication, comprising the actions of: transmitting a signal which includes first data which has been spread by a first long code, and which also includes, intermittently but not continuously, successive portions of a comma-free block code which provides at least partial identification of said first code, and a shared code which does not even partially identify said first long code; wherein said block code and said shared code are not spread by said first long code.

Detailed Description Text (173):
According to another disclosed class of innovative embodiments, there is provided: a method for operating a mobile station, comprising the steps of: detecting, when possible, an unspread code-identifying block code, in the transmission of a new base station with which communication is desired to be established; and deriving at least some information about the possible identity of a long code from said block of symbols in combination; and deriving at least some information about the phase of said long code from the phase of said block code.

Detailed Description Text (174):
According to another disclosed class of innovative embodiments, there is provided: a communications system comprising, in combination: a plurality of base stations executing a method of spread spectrum communication, comprising the action of: transmitting a signal which at least intermittently includes both first data which has been spread by a first long code, and also second data which is transmitted intermittently, and has not been spread by said first long code; and a plurality of receivers executing a method for operating a mobile station, comprising the steps of: detecting, when possible, an unspread code-identifying block code, in the transmission of a new base station with which communication is desired to be established; and deriving at least some information about the possible identity of a long code from said block of symbols in combination; and deriving at least some information about the phase of said long code from the phase of said block code; wherein said second data successively defines portions of a block code which provides at least partial identification of said first code.

Detailed Description Text (176):
According to another disclosed class of innovative embodiments, there is provided: a system of spread spectrum communication, comprising: a base station which transmits a signal, comprising: first data which has been spread by a first long code; successive portions of a comma-free block code, transmitted intermittently but not continuously, which provide at least partial identification of said first code, which is not spread by said first long code; and a shared code which does not even partially identify said first long code and which is not spread by said first long code; and a receiver which receives said signal.

Detailed Description Text (177):
According to another disclosed class of innovative embodiments, there is provided: a system of spread spectrum communication, comprising: a base station; and a receiver which detects, when possible, an unspread code-identifying block code, in the transmission of a said base station with which communication is desired to be established; and which derives at least some information about the possible identity of a long code transmitted from said base station from said block of symbols in combination; and derives at least some information about the phase of said long code from the phase of said block code.

Detailed Description Text (182):
For another example, the Reed-Solomon codes used in the presently preferred embodiment can of course be replaced by other codes, preferably comma-free block codes. Such codes can include BCH, Hamming codes, or other more powerful error-correcting codes. The length of such codes should preferably evenly divide into the length of the long codes. Alternatively, the length of the code words could be multiples of the length of the long codes.

Detailed Description Text (186):
In another alternative embodiment, where the set of comma-free block codes (within the constraints of acceptable minimum distance) is more than twice the number of

stations, multiple block codes can be assigned to each base station. This permits the station to be uniquely identified within less time than is required for one repetition of the long code word. For example, within the context of the preferred embodiment-described above, TWO comma-free 8-symbol codes can be assigned to each station (transmitted ABABAB), so that as soon as the mobile recognizes the block code there is no phase ambiguity. This allows for the use of shorter block codes as well.

CLAIMS:

3. The method of claim 1 wherein the sequence of short code symbols is selected from a set of comma free codes.

7. The method of claim 1 wherein the first long code is a linear code with a maximum minimum distance.

8. The method of claim 1 wherein the first long code is an (n,k) linear code with a minimum distance of n-k+1.

9. A method for operating a mobile station, comprising the steps of:

detecting a plurality of unspread long code marker symbols periodically transmitted by a base station, with which communication is desired to be established, on a first channel among symbols that are scrambled according to a long code assigned to the base station;

detecting, on a second channel, a sequence of short code symbols, each short code symbol transmitted by the base station synchronously with the long code marker symbol, where each short code symbol in the sequence differing from other short code symbols in the sequence so that the sequence has a unique cyclical shift;

deriving the identity of a subset of long codes to which said long belongs from the combination of the detected sequence of short code symbols; and

deriving frame timing of the long code from the position of the detected short code symbols within the sequence.

11. The method of claim 9 wherein said long code is a linear code with a maximum minimum distance.

13. The system of claim 12 wherein the sequence of short code symbols is selected from a set of comma free codes.

15. The system of claim 12 wherein the first long code is a linear code with a maximum minimum distance.

16. A system of spread spectrum communication, comprising:

a base station; and

a receiver for detecting a plurality of unspread long code marker symbols periodically transmitted by said base station, with which communication is desired to be established, on a first channel among symbols that are scrambled according to a long code assigned to the base station; for detecting, on a second channel, a sequence of short code symbols, each short code symbol transmitted by the base station synchronously with the long code marker symbol, where each short code symbol in the sequence differing from other short code symbols in the sequence so that the sequence has a unique cyclical shift; and for deriving the identity of a subset of long codes to which said long code belongs from the combination of the detected sequence of short code symbols; and for deriving frame timing of the long code from the position of the detected short code symbols within the sequence.